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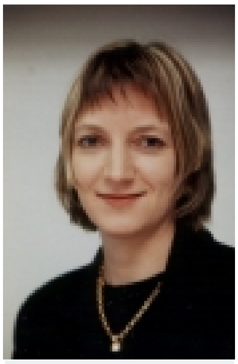
Evaluation of Green Concrete Types



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ABSTRACT

The goal of the Centre for Green Concrete is to reduce the environmental impact of concrete. Mix designs and results of different green concrete types are shown. Fulfilment of environmental goals is indicated by an example of a life cycle screening of a bridge column.

Key words: CO_2, residual products, green concrete, mix design, life cycle screening.

1. INTRODUCTION

In Denmark a centre for Resource Saving Concrete Structures (short name Centre for Green Concrete) is formed with the aim of reducing environmental impact from concrete. To enable this, new technology is developed. The technology considers all phases of a concrete construction's life cycle, i.e. structural design, specification, manufacturing, maintenance, and it includes all aspects of performance. An overview of the centre is given in /1/. In this article an evaluation is given on the different investigated green concrete types.

2. FOUR WAYS TO PRODUCE GREEN CONCRETE

Four ways to produce green concrete are being investigated.

1. To increase the use of conventional residual products, i.e. fly ash in large quantities.
2. To use residual products from the concrete industry, i.e. stone dust (from crushing of aggregate) and concrete slurry (from washing of mixers and other equipment).
3. To use residual products from other industries not traditionally used in concrete, i.e. fly ash from bio fuels and sewage sludge incineration ash (from sewage treatment plants).
4. To use new types of cement with reduced environmental impact (mineralised cement, limestone addition, waste-derived fuels).

The concrete types selected for testing are shown below for concrete in passive (P) and aggressive (A) environmental class, respectively. It can be seen that the four principles of producing green concrete are combined in order to achieve the most environmentally friendly concrete. All the concrete types fulfil the technical goals described in /1/.

PR	Reference concrete
P2	50% fly ash and 10% kiln dust of powder
P3	17% sewage sludge incineration ash of powder
P5	Concrete slurry
P6	100% stone dust of sand
P7	30% fly ash from bio fuels of powder

AR	Reference concrete
A0	Cement with reduced environmental impact
A1	40% fly ash of powder and cement with reduced environmental impact
A3	10% sewage sludge incineration ash of powder and cement with reduced environmental impact.
A5	Concrete slurry
A6	50% stone dust of sand

3. PRELIMINARY RESULTS

Results from investigation of mechanical properties of a green concrete show that these do not differ significantly from the mechanical properties of the reference concrete, see /2/. Results from investigation of workmanship show that some of the green concrete may lose workability more quickly than the reference concrete, be more adhesive or require a longer resting time before finishing can begin. It is expected that some of these problems can be solved by optimising the type and the amount of chemical admixtures. An evaluation of the practical aspects seen from the concrete manufacturers point of view is seen in /3/. It seems possible to produce these types of green concrete, which is just as durable as conventional concrete, /4/.

It is difficult to obtain a satisfactory air void structure for the concrete with large quantities of fly ash for aggressive environmental class (A1). When the correct mix design has been achieved, an expanded control at the manufacturing site is needed.

Concrete with sewage sludge incineration ash (P3 and A3) has been subjected to further investigations than the other green concrete types because the P3 showed lower compressive strength. No explanation for this has been found yet. Because of the high P_2O_5 content in the sewage sludge incineration ash it can not be rejected that a new durability problem or deterioration problem might occur.

4. LIFE CYCLE SCREENING

The environmental goals, see /1/, are valid for the whole life cycle of a concrete structure and not for the concrete mix design. Therefore, life cycle screening will be carried out with the Demonstration Bridge as an example. A preliminary study has been performed for a bridge column made of three different design principles compared to a reference principle. An example of a result is shown in figure 1 for sources of CO_2 emission in the life cycle. Column R is a reference column. Column A is a column with a green concrete type (A1). Column B is a column with stainless steel reinforcement and column C is a column with a permanent stainless steel cladding that replaces traditional shuttering. The lifetime is 50 years for all columns.

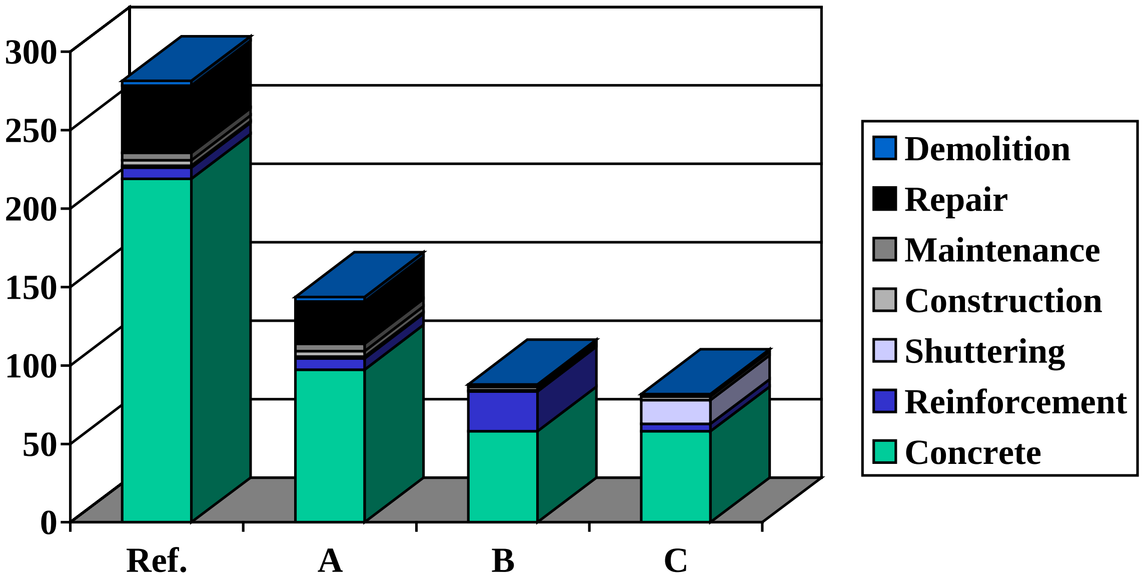

Figure 1 Sources of CO_2 emission for four types of columns

It can be seen that the CO_2 goal of 30% reduction is achieved for all three green columns. It can also be seen that concrete raw materials and repair are the main sources to the CO_2 emission.

5. CONCLUSION

The results obtained by the Danish Centre for Green Concrete show that it is possible to produce green concrete types where the properties such as durability, workmanship and mechanical properties are just as good as for ordinary concrete. An example of a life cycle screening of selected concrete types used in a bridge columns indicate that the environmental goals set up in the centre are fulfilled.

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